

**(19) World Intellectual Property Organization  
International Bureau**



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

**(43) International Publication Date**  
**31 October 2002 (31.10.2002)**

**PCT**

**(10) International Publication Number**  
**WO 02/086286 A2**

**(51) International Patent Classification<sup>7</sup>: E21B 43/10**

**Michael [GB/GB];** Blackchambers, Westhill, Aberdeenshire AB32 7BU (GB).

**(21) International Application Number:** PCT/GB02/01879

**(74) Agent: MURGITROYD & COMPANY; 165-169 Scotland Street, Glasgow G5 8PL (GB).**

**(22) International Filing Date:** 24 April 2002 (24.04.2002)

(25) Filing Language: English

**(81) Designated States (national):** AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(26) Publication Language: English

(30) Priority Data:  
0109993.6 24 April 2001 (24.04.2001) GB

**(71) Applicant (for all designated States except US): E2 TECH LIMITED** [GB/NL]; c/o Shell International B.V., P.O. Box 384, NL-2501 CJ The Hague (NL).

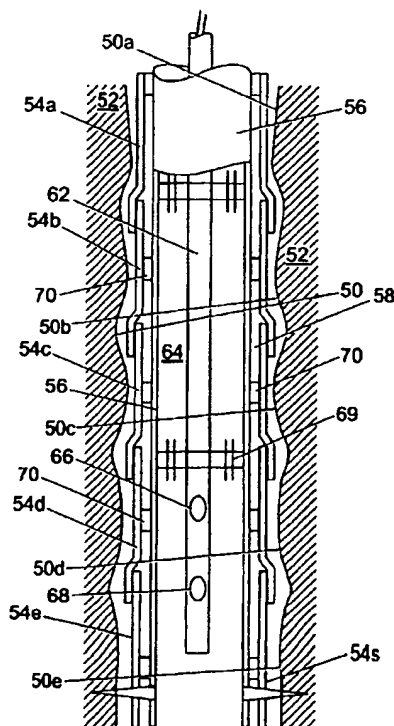
**(84) Designated States (regional):** ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent

**(72) Inventor; and**

(75) Inventor/Applicant (for US only): **BURGE, Philip,**

[Continued on next page]

**(54) Title: METHOD OF AND APPARATUS FOR CASING A BOREHOLE**



**(57) Abstract:** Methods of and apparatus for drilling, casing and/or completing a borehole (50) wherein one or more portions (50a to 50e) of the borehole (50) are drilled into a formation (52) at a single diameter along the entire length or depth of the or each portion (50a to 50e) of the borehole (50). An expandable tubular member (54a to 54e) is then located within the or each portion (50a to 50e) of the borehole (50) and radially expanded in the or each portion (50a to 50e) to line and/or case it or them. Optionally, a corrosion resistant member (56) and/or a service string (62) can be located in the borehole (50). An advantage of certain embodiments is that a single diameter borehole (50) is formed along the entire length or depth thereof.

**WO 02/086286 A2**

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

— *without international search report and to be republished upon receipt of that report*

1     "Method of and Apparatus for Casing a Borehole"

2

3     The present invention relates to a method of  
4     drilling, casing and/or completing a borehole, and  
5     in particular to a method of drilling, casing and/or  
6     cladding a borehole. The invention also provides  
7     apparatus for completing a borehole. It will be  
8     understood that use of the term "borehole" herein is  
9     a reference to a bore that has been drilled into a  
10    formation to allow the recovery of hydrocarbons (or  
11    other fluids) therefrom as is conventional in the  
12    art.

13

14    When a borehole has been drilled into a formation to  
15    facilitate, for example, the recovery of  
16    hydrocarbons from a well or reservoir, the formation  
17    surrounding the borehole is typically lined with a  
18    casing. Casing is installed to prevent the  
19    formation around the borehole from collapsing, and  
20    additionally to prevent unwanted fluids flowing from  
21    the surrounding formation into the borehole, and

1 similarly, to prevent fluids from within the  
2 borehole escaping into the surrounding formation.

3  
4 Referring to Fig. 1 there is shown a conventional  
5 borehole 10 that has been drilled into a formation  
6 12. It should be noted that Fig. 1 is not to scale.  
7 Borehole 10 is drilled with a relatively large  
8 diameter at or near surface 14, and it will be  
9 appreciated that surface 14 could be below sea  
10 level.

11  
12 A relatively large outer diameter (OD) casing 16 is  
13 then inserted into borehole 10 and cemented into  
14 place using cement 18 in a conventional manner. The  
15 cementing process typically involves filling an  
16 annulus between the casing 16 and the surrounding  
17 formation 12 with the cement 18 by pumping the  
18 cement 18 into the casing 16 followed by a rubber or  
19 other plug (not shown) on top of the cement 18.  
20 Thereafter, drilling fluid or the like is pumped  
21 down the casing 16 above the plug and the cement 18  
22 is pushed out of the bottom of the casing 16 and up  
23 into the annulus between the casing 16 and the  
24 formation 12, as shown in Fig. 1. Pumping of  
25 drilling fluid (and thus the cement 18) is stopped  
26 when the plug reaches the bottom of the casing 16  
27 and the borehole 10 must be left, typically for  
28 several hours, whilst the cement sets.

29  
30 Thereafter, a smaller diameter borehole 20 is  
31 drilled through the cement 18 into the formation 12  
32 and a subsequent casing 22 of smaller OD than the

1 casing 16 is passed through the casing 16 above and  
2 the borehole 20. The diameter of the drill bit that  
3 is used to drill borehole 20 is typically smaller  
4 than the drill bit used to drill borehole 10, and is  
5 typically smaller than an inside diameter (ID) of  
6 the casing 16. Casing 22 is then cemented into  
7 place using cement 24 in the conventional manner, as  
8 described above. The OD of the subsequent casing 22  
9 is limited by the inner diameter of the preceding  
10 casing 16. The cement 24 is then left for a further  
11 period of several hours to set.

12

13 A smaller diameter borehole 26 is then drilled into  
14 the cement 24 and into the formation 12, and another  
15 casing 28 is then passed through borehole 26 and the  
16 casing 22 above. As before, the diameter of the  
17 drill bit used to drill borehole 26 is typically  
18 smaller than the drill bit used to drill boreholes  
19 10, 20, and typically smaller than the ID of the  
20 casing 22. Casing 28 is then cemented into place  
21 using cement 30 in the conventional manner described  
22 above. The cement 30 is typically left for a  
23 further period of several hours to set. The ID of  
24 the casing 22 thus limits the OD of casing 28.

25

26 Finally, a smaller diameter borehole 32 is drilled  
27 into cement 30 and into formation 12, and another  
28 casing 34 of smaller OD than casing 28 is passed  
29 through casing 28. Again, the diameter of the drill  
30 bit used to drill borehole 32 is smaller than those  
31 used to drill the preceding boreholes 10, 20, 26,  
32 and smaller than the ID of casing 28. Cement 36 is

1 then used to secure casing 34 within borehole 32  
2 using the conventional manner described above. The  
3 cement 36 is typically left for a further period of  
4 several hours to set.

5  
6 Thus, the casings 16, 22, 28, 34 are cascaded with  
7 the diameters of the successive portions of casing  
8 reducing as the depth of the borehole 10, 20, 26, 32  
9 increases. It will be appreciated that the depth of  
10 the borehole 10, 20, 26, 32 may be in the order of  
11 several kilometres and the example shown in Fig. 1  
12 is representative only.

13  
14 The successive reduction in diameter of casing  
15 results in a casing with a relatively small ID near  
16 the bottom of the borehole 32 at or near a formation  
17 payzone. The narrow ID could limit the amount of  
18 hydrocarbons that can be recovered. In addition,  
19 the relatively large diameter borehole 10 at the top  
20 of the well involves increased costs due to the  
21 large drill bits required, heavy equipment for  
22 handling the larger casing, and increased volumes of  
23 drill fluid that are required.

24  
25 Once the casing portions 16, 22, 28, 34 have been  
26 cemented into place, the borehole is then  
27 "completed". This involves installing a completion  
28 string 38 within the IDs of the casing portions 16,  
29 22, 28, 34. The OD of the completion string 38 is  
30 thus limited by the ID of the lowermost casing 34,  
31 which in turn is limited by the IDs of the casings  
32 16, 22, 28 above, and this can limit the amount of

1 hydrocarbons that can be recovered from a reservoir  
2 40. The completion string 38 is typically of a  
3 corrosion resistant material as corrosive chemicals  
4 in the formation 12 and/or the reservoir 40 such as  
5 H<sub>2</sub>S can be mixed with the hydrocarbons from the  
6 reservoir 40 flowing up through the string 38 to the  
7 surface 14. The flow of hydrocarbons is indicated  
8 schematically by arrows 42 in Fig. 1.

9  
10 A packer 44 or the like is used at or near a lower  
11 end of the lowermost casing 34 to isolate the  
12 annulus and thus prevent hydrocarbons from flowing  
13 up it. Also, a safety valve (not shown) is  
14 typically located in the completion string 38 at or  
15 near an upper end thereof, and is used to prevent  
16 the flow of hydrocarbons to the surface in the event  
17 of an emergency, as is known in the art. The  
18 completion string 38 may also contain various flow  
19 control devices to control the flow of hydrocarbons,  
20 and downhole sensing and measuring apparatus to  
21 monitor the flow rate, temperature and other  
22 parameters of the produced fluids.

23  
24 According to a first aspect of the present invention  
25 there is provided a method of drilling and casing a  
26 borehole, the method comprising the steps of a)  
27 drilling a portion of the borehole into a formation,  
28 b) providing an expandable tubular member, c)  
29 running the tubular member into the portion of the  
30 borehole, and d) radially expanding the member.  
31

1 The method preferably includes the additional steps  
2 of drilling one or more further portions of the  
3 borehole extending from the existing portion of the  
4 borehole, providing one or more further expandable  
5 members, running the or each expandable member into  
6 the or each further portions of the borehole, and  
7 radially expanding the or each member in the or each  
8 further portion of the borehole. This process can  
9 then be repeated until the required depth of the  
10 overall borehole is reached.

11  
12 Preferably, the or each portion of the borehole is  
13 drilled at approximately the same diameter as the  
14 existing portion(s) of the borehole. Thus, all  
15 boreholes are drilled and cased at substantially the  
16 same diameter. This is advantageous because it  
17 requires only a single sized drill bit to be used  
18 instead of a number of different sized bits, and  
19 also reduces the amount of time spent in drilling  
20 and casing as there is no requirement to change to  
21 different sized bits as the borehole increases in  
22 depth.

23  
24 The or each portion of the borehole typically  
25 extends the borehole into the formation from the or  
26 each existing portion. Alternatively, or  
27 additionally, the or each portion of the borehole  
28 may comprises one or more lateral and/or horizontal  
29 boreholes drilled from the or each existing  
30 borehole.

31



1 According to a second aspect of the present  
2 invention there is provided apparatus for casing a  
3 borehole, the apparatus comprising a length of  
4 expandable tubular member, and an expander device  
5 that is capable of radially expanding the member in  
6 the borehole.

7  
8 A drill bit is typically used to drill the or each  
9 portion of the borehole into the formation. The  
10 drill bit is typically provided with one or more  
11 cutting elements that are preferably capable of  
12 assuming a retracted configuration and an extended  
13 configuration. In the retracted configuration, the  
14 drill bit can be passed through expandable members  
15 that have been expanded into contact with the  
16 borehole. In the expanded configuration, the drill  
17 bit can be used to drill a borehole below an  
18 expandable member that has been previously  
19 installed. An underreamer may be used, for example.

20  
21 Alternatively, a single diameter drill bit can be  
22 used together with an underreamer.

23  
24 The or each expandable tubular member can be of a  
25 length that is substantially the same length as the  
26 or each portion of the borehole. This provides the  
27 advantage that the entire length of the or each  
28 portion of the borehole can be cased using the same  
29 member. The or each length of expandable tubular  
30 member can be provided by coupling discrete lengths  
31 of expandable tubular member together (e.g. using

1 screw threads), or by using a roll, reel, coil or  
2 the like of expandable tubular member.

3 Alternatively, the or each length of tubular member  
4 may comprise a plurality of discrete lengths that  
5 are inserted into the or each portion of the  
6 borehole in an overlapping arrangement so that an  
7 upper end of a subsequent member overlaps a lower  
8 end of a previous member.

9

10 The or each expandable tubular member is typically  
11 radially expanded until at least a portion of an  
12 outer surface of the member contacts an inner  
13 surface of the or each portion of the borehole. It  
14 will be appreciated that the outer surface of the  
15 member need not contact the or each portion of the  
16 borehole. For example, the expandable tubular  
17 member may be provided with a friction and/or  
18 sealing material (e.g. rubber) on its outer surface,  
19 where the material typically contacts the or each  
20 portion of the borehole. Alternatively, the  
21 expandable tubular member (with or without a  
22 friction and/or sealing material) can be radially  
23 expanded within the or each portion of the borehole  
24 so that an annulus is created between an outer  
25 surface of the member and the or each portion of the  
26 borehole, the annulus then being filled with cement  
27 to hold the member in place.

28

29 Also, one or more spacers or the like may be used  
30 between the or each expandable tubular member and  
31 the or each portion of the borehole.

32

1     The method typically includes one, some or all of  
2     the additional steps of providing an expander  
3     device, and running the expander device into the  
4     expandable tubular member to radially expand the  
5     member.

6  
7     Optionally, the method includes one, some or all of  
8     the additional steps of resting the or each  
9     expandable tubular member on a portion of the  
10    expander device, and pushing or pulling the expander  
11    device through the member to radially expand the  
12    member in the or each portion of the borehole.

13  
14    Optionally, the method includes the additional step  
15    of anchoring at least a portion of the member,  
16    typically at or near a starting position of the  
17    expander device.

18  
19    The method typically includes the additional steps  
20    of providing a drill string, coiled tubing string or  
21    the like, and attaching the expander device to the  
22    string.

23  
24    Optionally, the method includes one, some or all of  
25    the additional steps of providing a corrosion  
26    resistant expandable tubular member, running the  
27    corrosion resistant expandable tubular member into  
28    the or each portion of the borehole, and radially  
29    expanding the corrosion resistant member.

30  
31    The corrosion resistant member is typically located  
32    within the expandable tubular member. The corrosion

1 resistant member is typically radially expanded  
2 until a portion thereof (e.g. an outer surface)  
3 contacts the expandable tubular member. It will be  
4 appreciated that the corrosion resistant member need  
5 not contact the expandable tubular member. A spacer  
6 or the like may be used therebetween, or a friction  
7 and/or sealing material applied to the outer surface  
8 of the corrosion resistant tubular member. Also,  
9 cement may be used between the members.

10

11 The corrosion resistant expandable tubular member is  
12 typically of a length that is substantially the same  
13 length as the or each portion of the borehole and/or  
14 the or each expandable tubular member. This  
15 provides the advantage that the entire length of the  
16 or each portion of the borehole can be cased using  
17 the same member. The length of the or each  
18 corrosion resistant expandable tubular member can be  
19 provided by coupling discrete lengths of corrosion  
20 resistant expandable tubular members together (e.g.  
21 using screw threads), or by using a roll, coil, reel  
22 or the like of corrosion resistant expandable  
23 tubular member. Alternatively, the length of  
24 corrosion resistant tubular member may comprise a  
25 plurality of discrete lengths that are inserted into  
26 the or each portion of the borehole in an  
27 overlapping arrangement so that a lower end of an  
28 upper member overlaps an upper end of a subsequent  
29 member. The corrosion resistant tubular member  
30 typically has a relatively thin wall thickness (e.g.  
31 in the order of 5mm or less).

32

1 Typically, at least a portion of the outer surface  
2 of the corrosion resistant tubular member contacts  
3 an inner surface of the expandable tubular member,  
4 although this is not essential.

5  
6 The corrosion resistant tubular member is typically  
7 required where the expandable tubular member is not  
8 corrosion resistant so that the hydrocarbons and  
9 other production fluids such as corrosive agents can  
10 flow up the corrosion resistant tubular member to  
11 the surface. Of course, the original expandable  
12 tubular member may be of a corrosion resistant  
13 material (or coated therewith) and thus there would  
14 be no requirement for a second member of corrosion  
15 resistant material. Additionally, the expandable  
16 tubular member and/or the corrosion resistant  
17 tubular member obviate the need to have an internal  
18 completion string to facilitate the recovery of  
19 hydrocarbons and eliminate an annulus between the  
20 completion string and the casing.

21  
22 Preferably, the method includes the additional step  
23 of providing a service string within the expandable  
24 tubular member. The service string is typically  
25 required as there is no annulus between the  
26 conventional completion string and the casing that  
27 is typically used for control cables and the like  
28 that control operation of various downhole tools and  
29 apparatus (e.g. packers, flow control devices,  
30 safety valves or the like), and electrical cables,  
31 wires etc.

32

1 The apparatus optionally includes a corrosion  
2 resistant tubular member. This member serves to  
3 facilitate the flow of hydrocarbons from a  
4 reservoir, well or the like to the surface.

5  
6 The apparatus preferably includes a service string  
7 or the like. The service string is typically  
8 located within the expandable and/or corrosion  
9 resistant member and is typically used as a conduit  
10 to house cables, wires and the like that are  
11 typically used to control downhole tools, apparatus  
12 and instruments. The service string may be provided  
13 with downhole apparatus and instruments (e.g. flow  
14 meters, temperature sensors etc).

15  
16 The recovered hydrocarbons typically flow up an  
17 annulus between the service string and the  
18 expandable tubular member and/or the corrosion  
19 resistant tubular member.

20  
21 The service string typically comprises a corrosion  
22 resistant tubular member. However, the service  
23 string may comprise any downhole tubular, such as a  
24 string of casing, liner or the like. The service  
25 string may comprise a roll or coil of tubing, or can  
26 be discrete lengths of preferably corrosion  
27 resistant tubular members that are coupled together  
28 (e.g. using screw threads). The corrosion resistant  
29 tubular member typically has a relatively thin wall  
30 thickness (e.g. of around 5mm or less).

31

1 The or each tubular member is preferably  
2 manufactured from a ductile material. Thus, the or  
3 each tubular member is capable of sustaining plastic  
4 deformation.

5  
6 Typically, the or each tubular member is a casing,  
7 liner, drill pipe, pipeline, conduit or the like.

8  
9 The expander device is typically manufactured from  
10 steel, a steel alloy, tungsten carbide etc.  
11 Alternatively, the expander device may be  
12 manufactured from ceramic, or a combination of  
13 steel, ceramic, tungsten carbide etc. The expander  
14 device is optionally flexible. The expander device  
15 is typically of a material that is harder than the  
16 member that is has to expand. It will be  
17 appreciated that only the portion(s) of the expander  
18 device that come into contact with the member need  
19 be of a harder material and/or coated therewith.

20  
21 The expander device is optionally provided with at  
22 least one seal. The seal typically comprises at  
23 least one O-ring.

24  
25 The expander device is typically pushed or pulled  
26 through the or each tubular member, pipeline,  
27 conduit or the like using fluid pressure.  
28 Alternatively, the device may be pigged along the or  
29 each tubular member or the like using a conventional  
30 pig or tractor. The device may also be pushed using  
31 a weight (from the string for example), or may be  
32 pulled through the or each tubular member or the

1     like (using drill pipe, rods, coiled tubing, a  
2     wireline or the like).

3

4     The or each tubular member is optionally temporarily  
5     anchored at an upper or lower end thereof using a  
6     mechanical or other anchoring device (e.g. a slip or  
7     packer), and facilitates radial expansion thereof.

8

9     An outer surface of the or each tubular member may  
10    be provided with a friction and/or sealing material  
11    that enhances the grip on the borehole or other  
12    member. The formation typically comprises one or  
13    more types of a resilient material.

14

15    Embodiments of the present invention shall now be  
16    described, by way of example only, with reference to  
17    the accompanying drawings in which:

18           Fig. 1 is a schematic representation of a prior  
19           art method of drilling and casing a borehole;  
20           Fig. 2 is an exemplary embodiment of apparatus  
21           for casing a borehole;

22           Fig. 3a is a front elevation showing a first  
23           configuration of a formation that can be  
24           applied to an outer surface of a portion of the  
25           apparatus of Fig. 2;

26           Fig. 3b is an end elevation of the formation of  
27           Fig. 3a;

28           Fig. 3c is an enlarged view of a portion of the  
29           formation of Figs 3a and 3b showing a profiled  
30           outer surface;

31           Fig. 4a is a front elevation of an alternative  
32           formation that can be applied to an outer



1 surface of a portion of the apparatus of Fig.  
2 2; and  
3 Fig. 4b is an end elevation of the formation of  
4 Fig. 4a.

5  
6 Referring to the drawings, Fig. 2 shows a particular  
7 embodiment of apparatus for casing a borehole 50  
8 that has been drilled into a formation 52 as is  
9 known in the art. The borehole 50 generally  
10 facilitates the recovery of hydrocarbons (or other  
11 fluids) from a reservoir or pay zone (not shown in  
12 Fig. 2).

13  
14 Like conventional methods for drilling boreholes,  
15 borehole 50 is made up of a number of individually  
16 drilled portions of borehole, illustrated in Fig. 2  
17 as boreholes 50a to 50e. It will be appreciated  
18 that Fig. 2 is not to scale and shows only a portion  
19 of the overall borehole 50 and the apparatus, and  
20 the number of individual portions of borehole 50a to  
21 50e that are required will vary depending upon the  
22 length or depth of the overall borehole 50.

23  
24 However, unlike conventional methods, the overall  
25 borehole 50 is drilled at a single diameter along  
26 its entire length or depth. This is achieved by  
27 drilling subsequent portions of borehole 50b to 50e  
28 through the first portion of borehole 50a at  
29 substantially the same diameter as the first portion  
30 of borehole 50a. A single diameter bit that is  
31 provided with one or more cutting elements can be  
32 used, where the or each cutting element is capable

1 of being moved between a retracted configuration and  
2 an extended configuration. In this way, the drill  
3 bit in the retracted configuration can be inserted  
4 through the first portion of borehole 50a that has  
5 already been drilled and cased, and then the or each  
6 cutting element can be moved to the extended  
7 configuration (e.g. by applying fluid pressure to  
8 the bit). Thus, the subsequent portions of the  
9 borehole 50b to 50e drilled can have substantially  
10 the same diameter as the preceding portions of the  
11 borehole 50a to 50d.

12

13 The apparatus includes a length of expandable casing  
14 54 that is preferably a single length of casing that  
15 is substantially the same length (or depth) as each  
16 individual portion of the borehole 50a to 50e. The  
17 casing 54 is shown in Fig. 2 as a number of casing  
18 portions of a discrete length with an overlap  
19 between each portion. However, it is possible to  
20 have the casing 54 made from a single piece of  
21 casing so that there is no overlap, although it is  
22 also possible to have a number of casing portions  
23 that are coupled together (e.g. by welding or screw  
24 threads) so that there is no overlap between  
25 successive casing portions. The casing 54 may be in  
26 the form of a roll, reel or coil of casing as is  
27 known in the art.

28

29 Casing 54 is preferably manufactured from a ductile  
30 material so that it is capable of sustaining plastic  
31 and/or elastic deformation. Casing 54 is typically

1 of carbon steel or a corrosion resistant alloy for  
2 example.

3

4 In use, the first portion of the borehole 50a is  
5 initially drilled so that the entire length or depth  
6 of the first portion of the borehole 50a is of  
7 substantially the same diameter. The diameter is  
8 typically slightly greater than an outer diameter  
9 (OD) of the casing 54 in an unexpanded state. The  
10 casing 54 is typically capable of sustaining plastic  
11 deformation to expand its OD by around 10% at least,  
12 although radial plastic deformation in the order of  
13 20% or more is possible. Thus, the diameter of the  
14 first portion of the borehole 50a (and thus the  
15 overall borehole 50) will be dependent upon the  
16 material used for the casing 54 and also the  
17 percentage of radial plastic deformation. It will  
18 be appreciated that use of the term radial plastic  
19 deformation is understood to be the use of an  
20 expander device (not shown) that is pushed or pulled  
21 through the casing 54 to impart a radial expansion  
22 force to the casing so that both the ID and the OD  
23 of the casing 54 increases.

24

25 Once the first portion of the borehole 50a has been  
26 drilled, it is typically lined or cased to prevent  
27 it from collapsing. In its simplest embodiment, a  
28 length of expandable casing 54a is inserted into the  
29 first portion of the borehole 50a. The length of  
30 the casing 54a is substantially the same as the  
31 depth or length of the first portion of the borehole  
32 50a. After the casing 54a has been run into the

1 first portion of the borehole 50a, an expander  
2 device is then forced through the casing 54a to  
3 radially expand at least a portion thereof, and  
4 preferably the entire length, so that the outer  
5 surface of the casing 54 preferably contacts the  
6 inner wall of the first portion of the borehole 50a.  
7 It will be appreciated that the outer surface of  
8 casing 54a need not contact the inner wall of the  
9 first portion of the borehole 50a, as will be  
10 described.

11  
12 The length of casing 54a may be in a number of  
13 different forms, for example, the length of casing  
14 54a could be from a roll, reel or coil of expandable  
15 tubing. Alternatively, the casing 54a can be made  
16 up from a plurality of discrete lengths of casing  
17 that are coupled together (e.g. by welding, screw  
18 threads or the like), or overlapped at each end.

19  
20 It is preferred, but not essential, that the entire  
21 length of the casing 54a is expanded in one pass of  
22 an expander device (not shown) through the casing  
23 54a. The expander device is typically a cone that  
24 is forced through the casing 54a to impart a radial  
25 expansion force to the casing 54a. The device can  
26 be of metal or a metal alloy (e.g. steel, tungsten  
27 carbide), ceramic or a combination of these  
28 materials and typically has an OD that is  
29 substantially the same as or slightly less than the  
30 final required ID of the (expanded) casing 54a. In  
31 this way, the first portion of the borehole 50a can

1 be cased in one trip of the device through the  
2 casing 54a.

3

4 The pliable casing 54a undergoes plastic deformation  
5 when expanded by the expander device as it is  
6 propelled, pushed or pulled through the casing 54a.

7 The expander device can be propelled along the  
8 casing 54a in a similar manner to a pipeline pig and  
9 may be pushed (using weight or fluid pressure for  
10 example) or pulled (using drill pipe, rods, coiled  
11 tubing, a wireline or the like).

12

13 The expander device is typically attached to a drill  
14 string, coil tubing string or the like and can be  
15 inserted into a lower part of the casing 54a that  
16 has been pre-expanded to house the device.

17 Thereafter, the device is pulled through the casing  
18 54a to impart a radial expansion force by pulling  
19 the drill string, coiled tubing string etc out of  
20 the casing 54a. Where the expander device is  
21 located in a pre-expanded portion of the casing 54a,  
22 the casing 54a can be rested on top of the device  
23 and lowered into the first portion of the borehole  
24 50a using the drill string, coiled tubing string or  
25 the like.

26

27 Alternatively, the expander device can be propelled  
28 or pushed through the casing 54a using a pig,  
29 tractor, fluid pressure or the like. It is possible  
30 that the expander device can be located at the top  
31 of the casing and propelled (using a tractor) or  
32 pushed (using fluid pressure, a drill string, or

1 weight from the string) through the casing 54a to  
2 impart a radial expansion force thereto.

3

4 The casing 54a may need to be temporarily anchored  
5 in the first portion 50a of the borehole 50 using a  
6 device, such as a packer, slips or the like.

7 However, where the expander device includes an  
8 inflatable element (e.g. a packer), then the  
9 inflatable element can be inflated in the pre-  
10 expanded portion (or elsewhere) thus forcing it  
11 radially outwards into contact with the first  
12 portion 50a of the borehole 50 and this provides an  
13 anchor for pulling the device through the casing  
14 54a. The expander device (e.g. a cone) can be  
15 releasably attached to the inflatable element so  
16 that the inflatable element can be left in the  
17 casing 54a to act as an anchor during expansion  
18 thereof.

19

20 The expandable casing 54a does not require to be  
21 cemented into place as it is typically held against  
22 the first portion 50a of the borehole 50 due to  
23 physical contact between an outer surface of the  
24 casing 54a and an inner wall of the first portion  
25 50a of the borehole 50, although cementing remains  
26 an option. The casing 54a need not contact the  
27 borehole 50 itself; it may be provided with a  
28 friction and/or sealing material, or other type of  
29 spacer or seal, between the casing 54a and the first  
30 portion 50a of the borehole 50. Thus, significant  
31 savings in terms of rig time and costs are provided  
32 as it is no longer necessary to cement each length

1 of conventional casing into place, the cement  
2 typically being left for several hours to cure. As  
3 each casing is of a different diameter, a borehole  
4 of equivalent or slightly larger diameter must be  
5 drilled into the formation for each diameter of  
6 casing which is then cemented into place, taking  
7 several hours to cure.

8

9 Once the first portion 50a of the borehole 50 has  
10 been drilled and the casing 54a installed, as  
11 described above, a second portion 50b of the  
12 borehole 50 is then drilled. The second portion 50b  
13 of the borehole 50 can be drilled using an  
14 expandable bit (e.g. a drill bit that is capable of  
15 assuming two different configurations). The  
16 expandable bit typically has a plurality of cutting  
17 elements that can be moved between first and second  
18 configurations. In the first configuration, the  
19 cutting elements are typically retracted so that the  
20 drill bit can be passed through the bore of  
21 previously drilled boreholes and/or pre-installed  
22 casings, liners etc. Once the bit has passed  
23 through the bores, the cutting elements can then be  
24 extended (e.g. by fluid pressure, centrifugal force  
25 or the like) to assume a cutting diameter that is  
26 slightly greater than the final or expanded outer  
27 diameter of the casing, liner etc.

28

29 Alternatively, the or each borehole portion 50b to  
30 50e can be drilled using a drill bit of a fixed  
31 diameter, and then an underreamer used to enlarge

1 the bore below a pre-installed portion of casing to  
2 allow a second casing to be installed therebelow.

3

4 Thus, the second portion 50b of the borehole 50 is  
5 drilled at substantially the same diameter as the  
6 first portion 50a of the borehole 50. Thus, there  
7 is no requirement to provide drill bits of varying  
8 cutting diameter to produce boreholes that reduce in  
9 diameter as the length or depth of the borehole  
10 increases, thus saving costs. Further, there is no  
11 requirement to provide casing or liner having  
12 different diameters, again saving costs. Further  
13 cost and time savings can be made as there is no  
14 requirement to change drill bits to vary the cutting  
15 diameter and the time taken to perform this.

16

17 Having drilled the second portion 50b of the  
18 borehole 50, a second casing 54b, similar to casing  
19 54a, is then installed and expanded into place as  
20 described above with reference to casing 54a. This  
21 has significant advantages as the casing 54a, 54b  
22 can be expanded sufficiently so that an outer  
23 surface 54s of each casing 54a, 54b contacts an  
24 inner wall of the borehole portions 50a, 50b.  
25 Consequently, the casing 54a, 54b is held in place  
26 due to frictional contact with the wall of the  
27 borehole portions 50a, 50b. Indeed, the casings  
28 54a, 54b can be expanded sufficiently so that they  
29 deform into the formation 52 and remain in place due  
30 to compression of the formation 52. This is  
31 advantageous because the casing 54a, 54b can be held  
32 in place without the use of cement. This, there is



1 no requirement to cement the casing 54a, 54b in  
2 place, thereby saving time and costs because the  
3 borehole portions 50a, 50b does not require to be  
4 left for several hours for each casing 54a, 54b to  
5 allow the cement to cure before further boreholes  
6 can be drilled.

7  
8 A third portion 50c of the borehole 50 is then  
9 drilled and cased using casing 54c in a similar  
10 manner to that described above. Further portions  
11 50d, 50e of the borehole 50 can then be drilled and  
12 cased using casing 54d, 54e and so on until the  
13 overall borehole 50 is at the required depth or  
14 length. Thus, the entire borehole 50 is drilled at  
15 substantially the same diameter over the full length  
16 or depth. Further advantages of embodiment of the  
17 present invention is that the entire length or depth  
18 of the overall borehole 50 can have a diameter that  
19 is sufficient to facilitate effective and non-  
20 restricted production of hydrocarbons and other  
21 fluid therefrom. This means that production from  
22 the borehole 50 can be increased, without adding to  
23 the costs and providing time savings in gaining  
24 access to the pay zone.

25  
26 It will be appreciated that an upper end of the  
27 subsequent casings 54b to 54e typically overlap a  
28 lower end of the previously installed casing (e.g.  
29 casing 54a), as shown in Fig. 2.

30  
31 It will be noted that drilling the borehole 50 at a  
32 single diameter over its entire length using

1 individual borehole portions 50a to 50e of  
2 substantially the same diameter, has other  
3 advantages over the conventional method described  
4 with reference to Fig. 1. In particular, the large  
5 drill bits and heavy equipment that are typically  
6 used towards the upper end of the borehole are not  
7 required, thus significantly reducing the costs.  
8 Other benefits and advantages include environmental  
9 benefits as less rock/cuttings are removed from the  
10 borehole that require to be disposed of. Also, only  
11 a borehole of one diameter is required. Thus, there  
12 is no requirement to drill a borehole of a first  
13 diameter using a relatively large drill bit and then  
14 drilling subsequent lower boreholes with drill bits  
15 that gradually reduce in diameter as the depth of  
16 the borehole increases. This significantly reduces  
17 the costs as less rig time is required because the  
18 requirement to periodically change a drill bit to a  
19 different sized bit is obviated. Furthermore, only  
20 a single-sized borehole is required and thus a  
21 plurality of different sized drill bits are not  
22 generally required, which also reduces costs. The  
23 rig time for drilling the borehole is substantially  
24 reduced with respect to conventional methods, as  
25 only a single diameter hole need be drilled over the  
26 entire length of the borehole.  
27  
28 Thus, the method of the present invention provides  
29 significant costs and timesavings as only a single  
30 diameter borehole need be drilled, and the borehole  
31 can be cased using a casing that has a substantially  
32 constant diameter over its entire length. As there

1 is no requirement to drill, case and then cement in  
2 a cascaded manner, the savings in terms of costs and  
3 rig time, rig power, rig size etc are considerable  
4 over conventional methods.

5

6 The outer surface of the casing 54 may optionally be  
7 provided with a friction and/or sealing material.

8 In this case, the friction and/or sealing material  
9 can be used to enhance the grip of the outer surface  
10 of the casing on the inner wall of the or each  
11 portion 50a to 50e of the borehole 50. Any suitable  
12 type of rubber or other resilient material can be  
13 used for this purpose.

14

15 Referring to Fig. 3, there is shown a formation  
16 generally designated 70, of a friction and/or  
17 sealing material that may be applied to an outer  
18 surface 54s of the casing 54 thereof. The formation  
19 70 typically comprises first and second bands 72, 74  
20 that are axially spaced-apart along a longitudinal  
21 axis of the casing 54. The first and second bands  
22 72, 74 are typically axially spaced by some  
23 distance, for example 3 inches (approximately 76mm).  
24 The first and second bands 72, 74 are preferably  
25 annular bands that extend circumferentially around  
26 the outer surface 54s of the casing 54, although  
27 this configuration is not essential. The first and  
28 second bands 72, 74 typically comprise 1-inch wide  
29 (approximately 26mm) bands of a first resilient  
30 material (e.g. a first type of rubber). The  
31 formation 70 need not extend around the full  
32 circumference of the surface 54s.

1

2     Located between the first and second bands 72, 74 is  
3     a third band 76 of a second resilient material (e.g.  
4     a second type of rubber). The third band 76  
5     preferably extends between the first and second  
6     bands 72, 74 and is thus typically 3 inches  
7     (approximately 76mm) wide.

8

9     The first and second bands 72, 74 are typically of  
10    the same depth as the third band 76, although the  
11    first and second bands may be of a slightly larger  
12    depth.

13

14    The first type of rubber (i.e. first and second  
15    bands 72, 74) is preferably of a harder consistency  
16    than the second type of rubber (i.e. third band 76).  
17    The first type of rubber is typically 90 durometer  
18    rubber, whereas the second type of rubber is  
19    typically 60 durometer rubber. Durometer is a  
20    conventional hardness scale for rubber.

21

22    The particular properties of the rubber or other  
23    resilient material may be of any suitable type and  
24    the hardnesses quoted are exemplary only. It  
25    should also be noted that the relative dimensions  
26    and spacing of the first, second and third bands 72,  
27    74, 76 are exemplary only and may be of any suitable  
28    dimensions and spacing.

29

30    As can be seen from Fig. 3c in particular, an outer  
31    face 76s of the third band 76 can be profiled. The  
32    outer face 76s is ribbed to enhance the grip of the

1 third band 76 on the borehole in which the casing 54  
2 is located. It will be appreciated that an outer  
3 surface of the first and second bands 72, 74 may  
4 also be profiled ( e.g. ribbed). The ribbed profile  
5 also helps when the casing 54 is expanded as it  
6 provides a space into which the compressed rubber  
7 can extend or deform into, as rubber is generally  
8 incompressible.

9  
10 The two outer bands 72, 74 being of a harder rubber  
11 provide a relatively high temperature seal and a  
12 back-up seal to the relatively softer rubber of the  
13 third band 76. The third band 76 typically provides  
14 a lower temperature seal.

15  
16 The two outer bands of rubber 72, 74 are provided  
17 with a number of circumferentially spaced-apart  
18 notches 78. In the embodiment shown, four  
19 equidistantly spaced notches 78 are provided, and as  
20 can be seen from Fig. 3b in particular, the notches  
21 78 do not extend through the entire depth of the  
22 rubber bands 72, 74. The notches 78 are used  
23 because the bands 72, 74 are of a relatively hard  
24 rubber material and this may stress, crack or break  
25 when the outer diameter of the casing 54 is radially  
26 expanded. The notches 78 provide a portion of the  
27 bands 72, 74 that is of lesser thickness than the  
28 rest of the bands 72, 74 and this portion can  
29 stretch when the casing 54 is expanded. The  
30 stretching of this portion substantially prevents  
31 the bands 72, 74 from cracking or breaking when the  
32 casing 54 is expanded. The notches 78 also provide

1 a space into which the rubber may deform or expand  
2 into when the casing 54 is expanded.

3

4 In use, the formation 70 is applied to the outer  
5 surface 54s of the (unexpanded) expandable casing  
6 54. The formation 70 may be applied at axially  
7 spaced-apart locations along the length of the  
8 casing 54, the spacing and number of formations 70  
9 being chosen to suit the particular application.

10

11 An alternative formation 80 that can be applied to  
12 the outer surface 54s of the casing 54 is shown in  
13 Figs 4a and 4b. The alternative formation 80 is in  
14 the form of a zigzag. In this embodiment, the  
15 formation 80 comprises a single (preferably annular)  
16 band of resilient material (e.g. rubber) that is,  
17 for example, of 90 durometers hardness and about 2.5  
18 inches (approximately 28mm) wide by around 0.12  
19 inches (approximately 3mm) deep.

20

21 To provide a zigzag pattern and hence increase the  
22 strength of the grip and/or seal that the formation  
23 80 provides in use, a number of slots 82a, 82b (e.g.  
24 20 in number) are milled into the band of rubber.  
25 The slots 82a, 82b are typically in the order of 0.2  
26 inches (approximately 5mm) wide by around 2 inches  
27 (approximately 50mm) long.

28

29 The slots 82a are milled at around 20  
30 circumferentially spaced-apart locations, with  
31 around 18° between each along one edge 84a of the  
32 band. The process is then repeated by milling

1 another 20 slots 82b on the other side 84b of the  
2 band, the slots 82b on the other side 84b being  
3 circumferentially offset by 9° from the slots 82a on  
4 the first side 84a. The slots 82a, 82b also provide  
5 a space into which the rubber of the formation 80  
6 can expand or deform into when the casing 54 is  
7 expanded.

8  
9 In use, the formation 80 is applied to the outer  
10 surface 54s of the expandable casing 54, as with  
11 formation 70. The formation 80 may be applied at a  
12 plurality of axially spaced-apart locations along  
13 the length of the casing 54, the spacing and number  
14 of formations 80 being chosen to suit the particular  
15 application.

16  
17 It is preferable that the casing 54 be made of a  
18 corrosion resistant material so that the casing 54  
19 can also be used as a production string up which  
20 hydrocarbons from the reservoir may flow to the  
21 surface. Of course, casing 54 may be coated with a  
22 corrosion resistant material. However, where this  
23 is not possible, it will be necessary to insert an  
24 additional length of cladding 56 that is of a  
25 corrosion resistant material inside the casing 54,  
26 as shown in Fig. 2. It should be noted that the  
27 corrosion resistant cladding 56 is not essential.  
28

29 The cladding 56 is preferably also of a ductile  
30 material that is also a corrosion resistant material  
31 so that it can be inserted into the casing 54 and

1 radially expanded so that its OD contacts the ID of  
2 the casing 54. In this way, the overall borehole 50  
3 (or portions thereof) can be lined with casing 54  
4 and clad with cladding 56 by installing the casing  
5 54 as described above, and then the cladding 56 is  
6 inserted into the casing 54 and then radially  
7 expanded so that it contacts an inner surface of the  
8 casing 54. Again, the cladding 56 need not contact  
9 the casing 54 as spacers or the like may be  
10 provided. Also, cement can optionally be used to  
11 fill the annulus between the casing 54 and the  
12 cladding 56.

13  
14 Cladding 56 is typically relatively thin (e.g. with  
15 a wall thickness of around 5mm or less) so that it  
16 is easy to radially expand, and also so that it does  
17 not adversely affect the size of the conduit through  
18 which the recovered hydrocarbons flow to the  
19 surface. Thus, the cladding 56 does not restrict  
20 the flow rate of the recovered hydrocarbons or other  
21 fluids.

22  
23 It will be appreciated that the cladding 56 may be  
24 provided with formation 70, formation 80 or the like  
25 to provide a seal in the annulus 58 between the  
26 cladding 56 and casing 54, as illustrated in Fig. 2.  
27 It will be generally appreciated that a seal in the  
28 annulus 58 will not be required where the cladding  
29 56 is expanded to fully contact the casing 54 as  
30 there will be no annulus. The seals provided by,  
31 for example, formations 70, 80 or any conventional  
32 method (e. g. a packer) prevent hydrocarbons from



1 the reservoir or well flowing up the annulus 58 and  
2 being lost into the surrounding formation.

3

4 Thus, the method may include the additional step of  
5 providing a length of cladding 56 where it is  
6 required to have a corrosion resistant material in  
7 the borehole 50 (e.g. if the casing 54 is not  
8 corrosion resistant or provided with a corrosion  
9 resistant coating). The cladding 56 can be the same  
10 length as the overall borehole 50, but it will be  
11 appreciated that the length of cladding 56 may  
12 comprise a number of discrete portions, or may be in  
13 the form of a coil, reel or roll for example. The  
14 cladding 56 is then run into the casing 54 and  
15 radially expanded. The cladding 56 can be radially  
16 expanded in the same way as the casing 54 e.g. by  
17 pushing, pulling or otherwise propelling the  
18 expander device therethrough.

19

20 The conventional method of drilling and completing a  
21 borehole generally provides a production annulus 46  
22 between the production string 38 and the casing 34  
23 (Fig. 1). The production annulus 46 is typically  
24 used to run control lines, wires etc from the  
25 surface to downhole, the lines etc being used for  
26 many different purposes such as transmitting power  
27 and data communications from the surface to  
28 apparatus located downhole.

29

30 The production annulus 46 typically acts as a  
31 service conduit also, that is it is usually used to  
32 gain access for remedial and repair operations.

1 Also, the service conduit is used to house cabling  
2 and downhole apparatus and instruments (e.g. flow  
3 sensors, temperature sensors and associated cabling  
4 etc) that monitor various parameters of the  
5 recovered hydrocarbons.

6

7 The service conduit (i.e. production annulus 46) is  
8 generally limited in size resulting in space and  
9 design constraints for the type of apparatus,  
10 instruments and cabling that can be inserted  
11 therein. The size limitation also presents other  
12 problems, such as making the annulus 46 difficult to  
13 access and it is also difficult to install downhole  
14 apparatus and instruments, cabling etc. The  
15 apparatus, instruments and cabling are often damaged  
16 as they are being run into the annulus 46, and there  
17 is also difficulty in passing the apparatus etc  
18 through pressure barriers such as packers.

19

20 If the apparatus or instruments fail or break down  
21 during installation or use, they must be retrieved  
22 from the annulus, which can be very expensive and  
23 time consuming.

24

25 Referring to Fig. 2, it will be noted that an  
26 annulus 58 is provided in the particular embodiment  
27 shown in Fig. 2 and this can be used for the control  
28 lines etc. However, there may be situations where  
29 there is no annulus 58 between the cladding 56 and  
30 the casing 54, for example where the casing 54 is  
31 also corrosion resistant so that the cladding 56 is  
32 not required, or where the cladding 56 is radially

1 expanded to fully contact the inner surface of the  
2 casing 54 or cement is used to fill the annulus 58.

3

4 Thus, the present invention also provides a service  
5 string 62 that is located within the cladding 56 in  
6 the embodiment shown. It will be noted that the  
7 service string 62 can be provided within the casing  
8 54 where no cladding 56 is used. The service string  
9 62 is of a relatively small OD so that it does not  
10 provide an obstruction to the hydrocarbons that will  
11 flow up an annulus 64 between the service string 62  
12 and the cladding 56 (or casing 54).

13

14 The service string 62 can be a string of any  
15 downhole tubular member, but is preferably in the  
16 form of a coil, roll or reel so that it can be  
17 easily dispensed and retrieved from the borehole 50.

18

19 The service string 62 is used to house the control  
20 wires, lines etc and any other control or electrical  
21 cables that are used to control or provide signals  
22 to and from downhole apparatus. The service string  
23 62 may incorporate the downhole apparatus and  
24 instruments, such as flow sensors 66 or intra-well  
25 sensors 68 etc. Thus, the service string 62 could  
26 house cabling that is between the downhole sensors  
27 66, 68 and the surface. The service string 62 may  
28 also be used for chemical injection and gas lift.

29

30 Also, the annulus 64 may contain other downhole  
31 apparatus or instruments, such as flow control  
32 devices 69 or the like. Thus, the service string 62

1 can be used to house any cabling between the flow  
2 control device 69 and the surface so that the device  
3 69 or other apparatus can be controlled and  
4 monitored.

5

6 Where a service string 62 is required, the method  
7 typically includes the additional steps of providing  
8 the service string 62 within the casing 54 or the  
9 cladding 56. The service string 62 is typically  
10 held within the casing 54 or the cladding 56 using  
11 any conventional means, e.g. seals, a packer or the  
12 like. The service string 62 can comprise a number  
13 of discrete portions of drill string for example, or  
14 could be a length of coiled tubing or the like.

15

16 Thus, the invention in certain embodiments provides  
17 a method and apparatus for casing a borehole that  
18 provides significant advantages over conventional  
19 methods. In particular, the method and apparatus of  
20 the invention in certain embodiments provide savings  
21 in terms of costs and rig time, and also obviate the  
22 need to drill different sized boreholes for each OD  
23 of casing. Additionally, there is no requirement to  
24 cement the casing into place as it is radially  
25 expanded to contact the borehole and is generally  
26 held in place due to a frictional contact between  
27 the casing and the borehole.

28

29 The service string in certain embodiments offers  
30 advantages over the conventional method because it  
31 provides a housing for downhole apparatus and  
32 instruments that can be pre-installed before the

1 string is run into the borehole. Thus, the  
2 instruments, cabling etc are protected as they are  
3 run into the borehole by the service string. Also,  
4 if the instruments, apparatus etc within the service  
5 string fail or break down, the service string can be  
6 easily withdrawn from the borehole and the  
7 instruments, apparatus etc repaired or replaced  
8 before the string is run back into the borehole.

9  
10 It will also be appreciated that embodiments of the  
11 present invention facilitate easy repair of damaged  
12 portions of casing, lining or cladding. The service  
13 string (where used) would be pulled out of the  
14 borehole, and a portion of casing, lining or  
15 cladding inserted into the borehole. The portion of  
16 casing, liner or cladding is located at or near the  
17 damaged portion that is to be repaired, and  
18 preferably straddles the damaged portion.  
19 Thereafter, the portion of casing, liner or cladding  
20 is then radially expanded using an expander device  
21 or an inflatable element (e.g. a packer) so that the  
22 portion of casing, liner or cladding is radially  
23 expanded and thus overlays the damaged portion of  
24 casing, liner or cladding. The entire length of the  
25 casing, liner or cladding need not be fully  
26 expanded, and the casing, liner or cladding can be  
27 tied back to the damaged portion by expanding each  
28 end thereof (e.g. using an inflatable packer).  
29 However, the portion of casing, liner or cladding  
30 that is not fully expanded will typically cause a  
31 restriction in the path of the hydrocarbons (or  
32 other fluids) that are being recovered, which could

1     limit the rate at which the hydrocarbons (or other  
2     fluids) can be recovered.

3

4     The portion of casing or cladding that is used for  
5     the repair is typically a thin-walled tubular with a  
6     wall thickness of 5mm or less so that there is no  
7     material change to the diameter of the annulus  
8     created between the service string and the cladding  
9     up which the hydrocarbons flow. Thus, there is no  
10    adverse affect on the flow rate of the recovered  
11    hydrocarbons.

12

13    Certain embodiments of the invention also provide  
14    advantages, as repair or maintenance (e.g. remedial)  
15    operations to the borehole, formation etc are  
16    simpler because a relatively large diameter of  
17    casing can be used along the entire length of the  
18    borehole. In conventional systems, these types of  
19    operation have to be performed from within the  
20    completion string. Restrictions in the ID of the  
21    completion string, for example due to safety valves,  
22    sensors and the like, can make these operations  
23    difficult. Certain embodiments of the present  
24    invention provide an unrestricted ID of casing so  
25    that the repair operations etc can be undertaken  
26    more easily. Even where a service string is used  
27    with the present invention, this is relatively small  
28    and can be removed to facilitate the repair  
29    operations etc, and thereafter replaced.

30

31    Modifications and improvements may be made to the  
32    foregoing without departing from the scope of the

1 present invention. For example, the tubular members  
2 described herein have been radially expanded using  
3 an expander device that imparts a plastic  
4 deformation to expand the member. It will be  
5 generally appreciated that the members can undergo  
6 radial expansion, where only a discrete length of  
7 the member is expanded using an inflatable device  
8 (e.g. a packer). Thereafter, the inflatable device  
9 is moved to an unexpanded portion and inflated to  
10 radially expand the next portion and so on.  
11

1     CLAIMS

2

3     1.    A method of drilling and/or casing a borehole,  
4     the method comprising the steps of a) drilling a  
5     portion (50a) of the borehole (50) into a formation  
6     (52); b) providing an expandable tubular member  
7     (54); c) running the expandable tubular member (54)  
8     into the portion (50a) of the borehole (50); and d)  
9     radially expanding the member (54).

10

11    2.    A method according to claim 1, the method  
12    including the additional steps of drilling one or  
13    more further portions (50b to 50e) of the borehole  
14    (50) extending from the existing portion (50a) of  
15    the borehole (50), providing one or more further  
16    expandable members (54b to 54e), running the or each  
17    expandable member (54b to 54e) into the or each  
18    further portions (50b to 50e) of the borehole (50),  
19    and radially expanding the or each expandable member  
20    (54b to 54e) in the or each further portions (50b to  
21    50e) of the borehole (5).

22

23    3.    A method according to claim 2, wherein the or  
24    each further portion (50b to 50e) of the borehole  
25    (50) is drilled at approximately the same diameter  
26    as the or each existing portion(s) (50a to 50d) of  
27    the borehole (50).

28

29    4.    A method according to claim 2 or claim 3,  
30    wherein the or each further portion (50b to 50e) of  
31    the borehole (50) extends into the formation (52)  
32    from the or each existing portion (50a to 50e).



1

2 5. A method according to any one of claims 2 to 4,  
3 wherein the or each portion (50b to 50e) of the  
4 borehole (50) comprises one or more lateral and/or  
5 horizontal boreholes drilled from the or each  
6 existing borehole (50a to 50d).

7

8 6. A method according to any preceding claim,  
9 wherein the method includes the additional step of  
10 providing a drill bit to drill the or each portion  
11 (50a to 50e) of the borehole (50) into the formation  
12 (52).

13

14 7. A method according to claim 6, wherein the  
15 drill bit is provided with one or more cutting  
16 elements that are capable of being moved between a  
17 retracted configuration and an extended  
18 configuration.

19

20 8. A method according to claim 7, the method  
21 including the additional step of moving the cutting  
22 elements between the retracted configuration and the  
23 extended configuration.

24

25 9. A method according to claim 8, wherein the step  
26 of moving the cutting elements includes the  
27 additional step of applying pressurised fluid to the  
28 drill bit.

29

30 10. A method according to claim 6, wherein a single  
31 diameter drill bit is used to drill the or each  
32 portion (50a to 50e) of the borehole (50).

1

2 11. A method according to claim 10, wherein the  
3 method includes the additional steps of providing an  
4 underreamer, running the underreamer into the or  
5 each portion (50a to 50e) of the borehole (50), and  
6 actuating the underreamer to increase the diameter  
7 of the or each portion (50a to 50e) of the borehole  
8 (50).

9

10 12. A method according to any preceding claim,  
11 wherein the or each expandable tubular member (54a  
12 to 54e) is radially expanded until at least a  
13 portion of an outer surface (54s) of the member (54a  
14 to 54e) contacts an inner surface of the or each  
15 portion (50a to 50e) of the borehole (50).

16

17 13. A method according to any one of claims 1 to  
18 11, wherein the expandable tubular member (54a to  
19 54e) is radially expanded within the or each portion  
20 (50a to 50e) of the borehole (50) so that an annulus  
21 is created between an outer surface (54s) of the  
22 member (54a to 54e) and the or each portion (50a to  
23 50e) of the borehole (50), and the method includes  
24 the additional step of filling the annulus with  
25 cement to hold the member (54a to 54e) in place.

26

27 14. A method according to any preceding claim,  
28 wherein the step of radially expanding the member  
29 (54a to 54e) includes the additional steps of  
30 providing an expander device, and running the  
31 expander device into the expandable tubular member

1 (54a to 54e) to radially expand the member (54a to  
2 54e).

3

4 15. A method according to claim 14, wherein the  
5 step of running the expander device includes the  
6 step of pushing and/or pulling the expander device  
7 through the member (54a to 54e) to radially expand  
8 the member (54a to 54e) in the or each portion (50a  
9 to 50e) of the borehole (50).

10

11 16. A method according to claim 14 or claim 15,  
12 wherein the method includes the additional step of  
13 resting the or each expandable tubular member (54a  
14 to 54e) on a portion of the expander device whilst  
15 the member (54a to 54e) and device are run into the  
16 or each portion (50a to 50e) of the borehole (50).

17

18 17. A method according to any one of claims 14 to  
19 16, wherein the method includes the additional step  
20 of anchoring at least a portion of the member (54a  
21 to 54e) at or near a starting position of the  
22 expander device.

23

24 18. A method according to any preceding claim, the  
25 method including one, some or all of the additional  
26 steps of e) providing a corrosion resistant  
27 expandable tubular member (56); f) running the  
28 corrosion resistant expandable tubular member (56)  
29 into the or each portion (50a to 50e) of the  
30 borehole (50); and g) radially expanding the  
31 corrosion resistant expandable tubular member (56).

32

1 19. A method according to claim 18, wherein the  
2 method includes repeating steps e) to f).

3 .

4 20. A method according to any preceding claim, the  
5 method including the additional step of providing a  
6 service string (62) within the expandable tubular  
7 member (54) and/or the corrosion resistant  
8 expandable tubular member (56).

9

10 21. Apparatus for casing a borehole , the apparatus  
11 comprising at least one length of expandable tubular  
12 member (54), and an expander device that is capable  
13 of radially expanding the member (54) in the  
14 borehole (50).

15

16 22. Apparatus according to claim 21, wherein the or  
17 each expandable tubular member (54a to 54e) is of a  
18 length that is substantially the same length as the  
19 or each portion (50a to 50e) of the borehole (50).

20

21 23. Apparatus according to claim 21 or claim 22,  
22 wherein the or each length of expandable tubular  
23 member (54a to 54e) is provided by coupling discrete  
24 lengths of expandable tubular member (54a to 54e)  
25 together.

26

27 24. Apparatus according to claim 21 or claim 22,  
28 wherein the or each length of expandable tubular  
29 member (54) is provided from a roll, reel, coil or  
30 drum of expandable tubular member (54).

31

1     25. Apparatus according to claim 21 or claim 22,  
2     wherein the or each length of expandable tubular  
3     member (54a to 54e) comprises a plurality of  
4     discrete lengths that are inserted into the or each  
5     portion (50a to 50e) of the borehole (50) in an  
6     overlapping arrangement so that one end of a  
7     subsequent member (54a to 54e) overlaps one end of a  
8     previous member (54a to 54e).

9  
10    26. Apparatus according to any one of claims 21 to  
11    25, wherein the or each expandable tubular member  
12    (54a to 54e) is provided with a friction and/or  
13    sealing material (70, 80) on its outer surface.

14  
15    27. Apparatus according to any one of claims 21 to  
16    26, wherein the apparatus includes one or more  
17    spacers located between the or each expandable  
18    tubular member (54a to 54e) and the or each portion  
19    (50a to 50e) of the borehole (50).

20  
21    28. Apparatus according to any one of claims 21 to  
22    27, wherein the or each expandable tubular member  
23    (54a to 54e) is of a corrosion resistant material,  
24    or coated therewith.

25  
26    29. Apparatus according to any one of claims 21 to  
27    28, wherein the apparatus includes at least one  
28    corrosion resistant expandable tubular member (56)  
29    located within the or each expandable tubular member  
30    (54a to 54e).

31

1 30. Apparatus according to claim 29, wherein the  
2 corrosion resistant expandable tubular member (56)  
3 is of a length that is substantially the same length  
4 as the or each portion (50a to 50e) of the borehole  
5 (50) and/or the or each expandable tubular member  
6 (54a to 54e).

7  
8 31. Apparatus according to claim 29 or claim 30,  
9 wherein the corrosion resistant expandable tubular  
10 member (56) has a wall thickness in the order of 5mm  
11 or less.

12  
13 32. Apparatus according to any one of claims 29 to  
14 31, wherein the apparatus includes a service string  
15 (62).

16  
17 33. Apparatus according to claim 32, wherein the  
18 service string (62) is located within the expandable  
19 tubular member (54a to 54e) and/or the corrosion  
20 resistant expandable tubular member (56).

21  
22 34. Apparatus according to claim 32 or claim 33,  
23 wherein the service string (62) is used as a conduit  
24 to house cables and wires that are used to control  
25 downhole tools, apparatus and instruments.

26  
27 35. Apparatus according to any one of claims 32 to  
28 34, wherein the service string (62) is provided with  
29 downhole tools, apparatus and instruments.

30

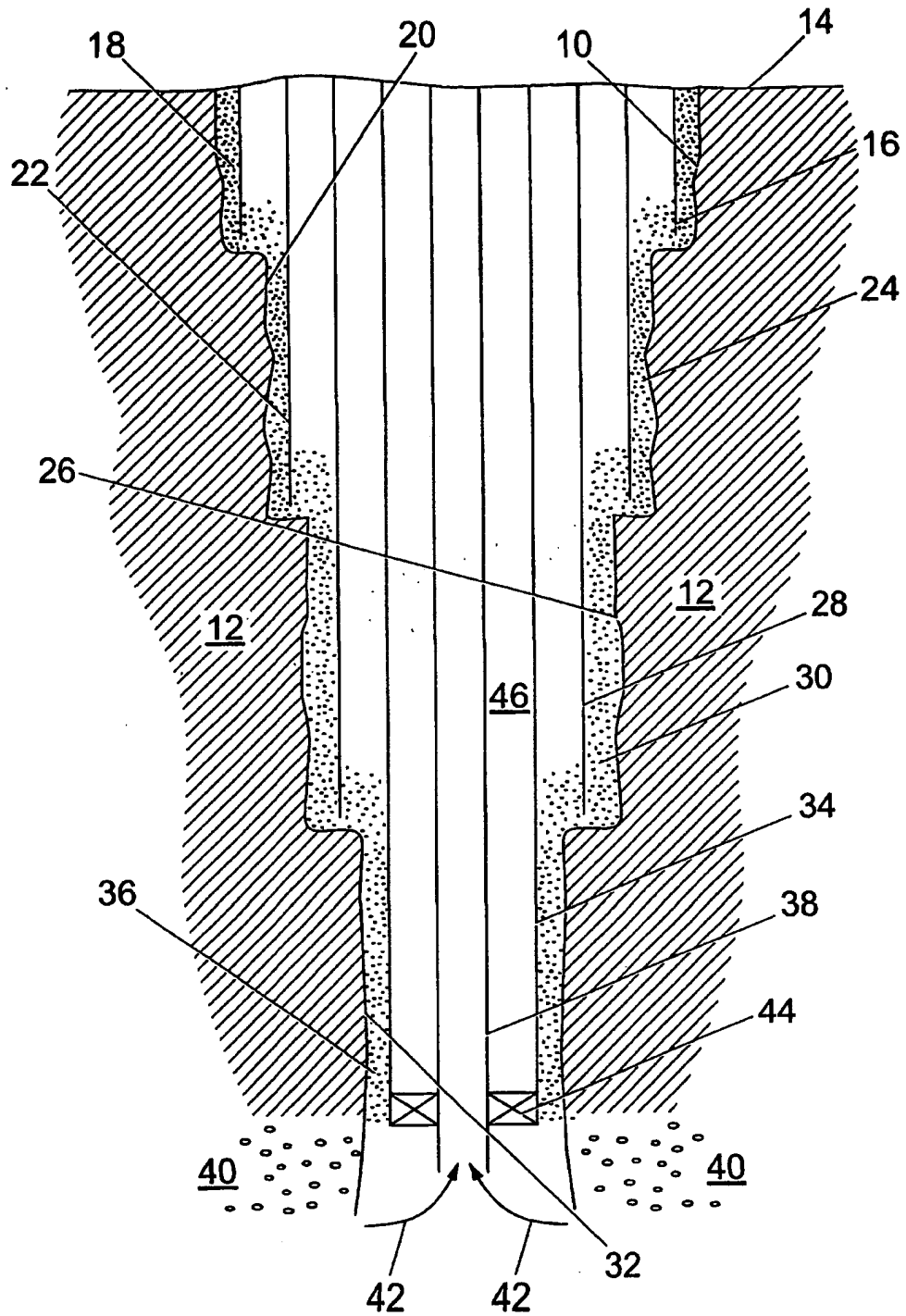
1     36. Apparatus according to any one of claims 32 to  
2     35, wherein the service string (62) comprises a  
3     corrosion resistant tubular member (56).

4

5     37. Apparatus according to any one of claims 32 to  
6     36, wherein the service string (62) has a wall  
7     thickness in the order of 5mm or less.

8

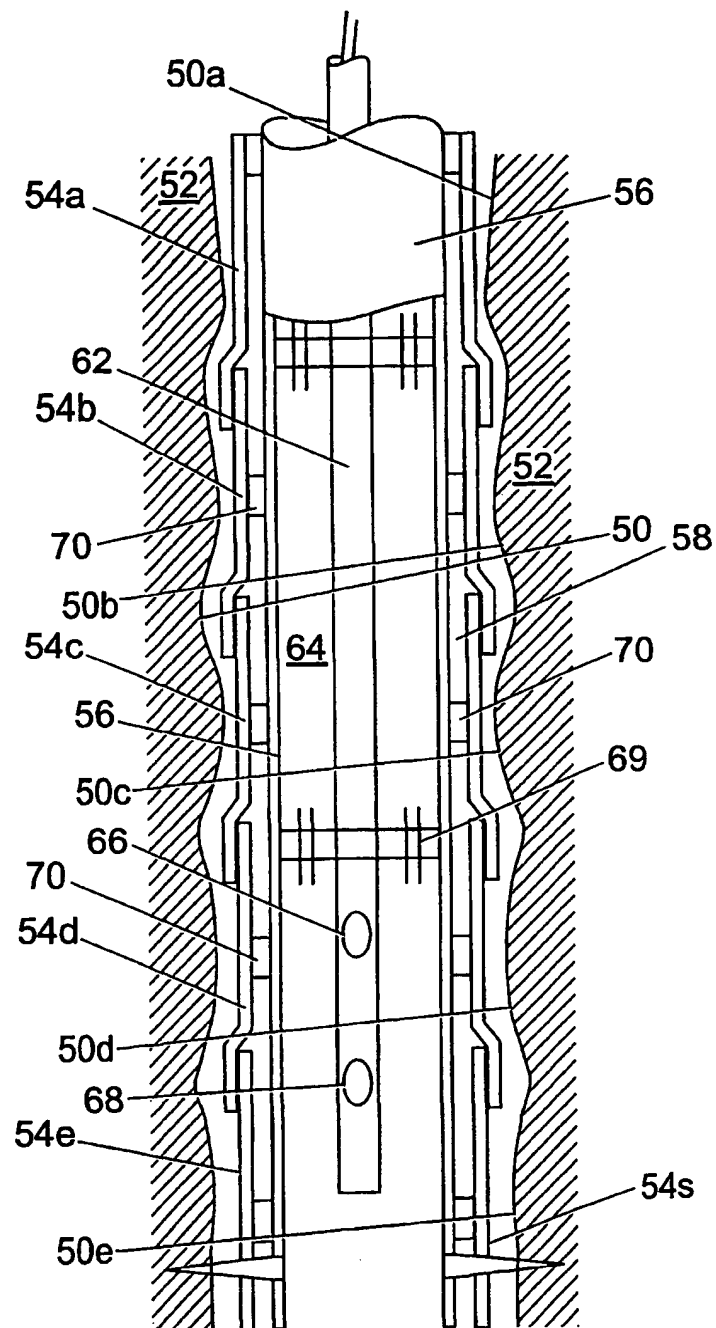
1 / 4

*Fig. 1*

SUBSTITUTE SHEET (RULE 26)

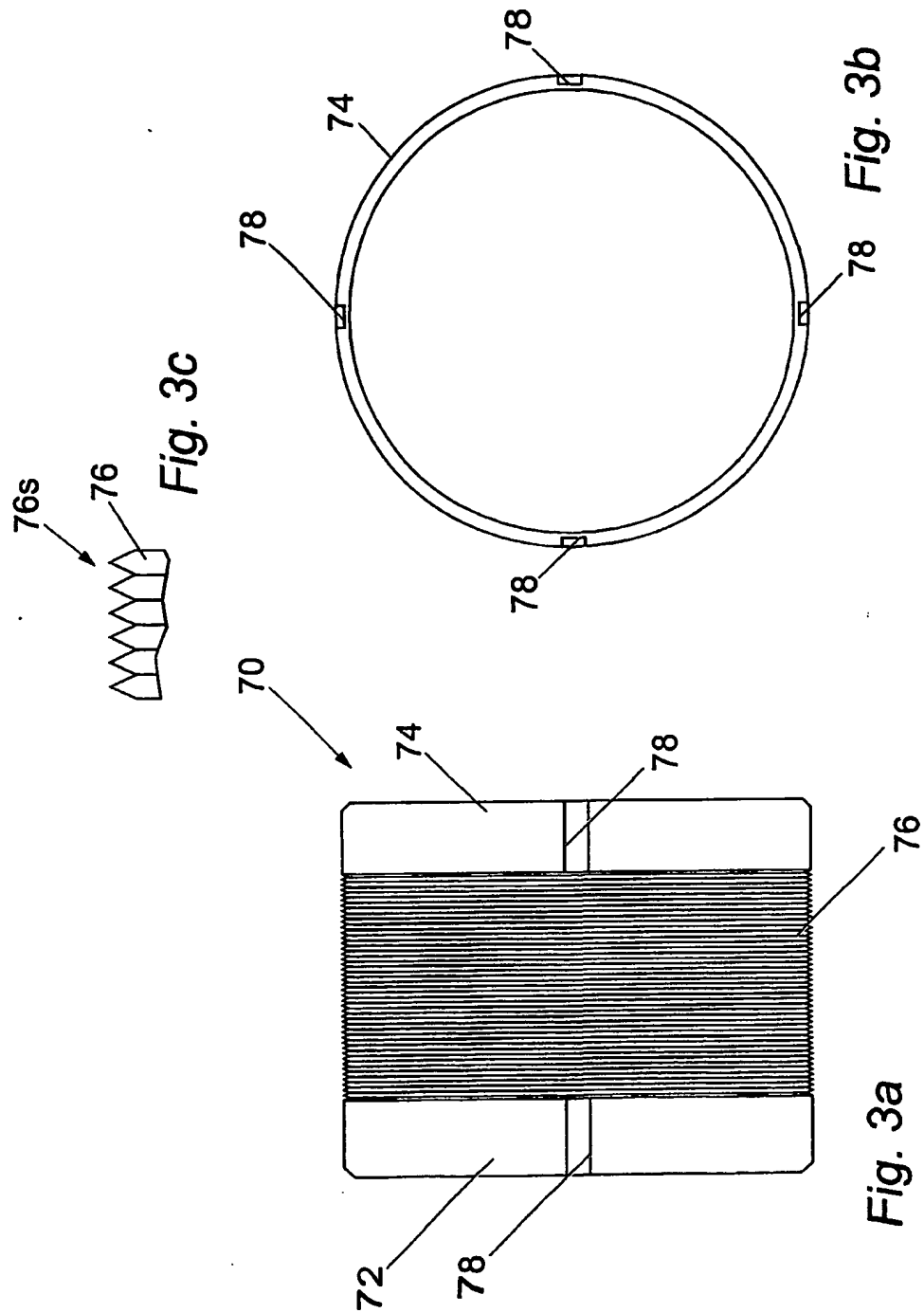


2 / 4

*Fig. 2*

SUBSTITUTE SHEET (RULE 26)

3 / 4



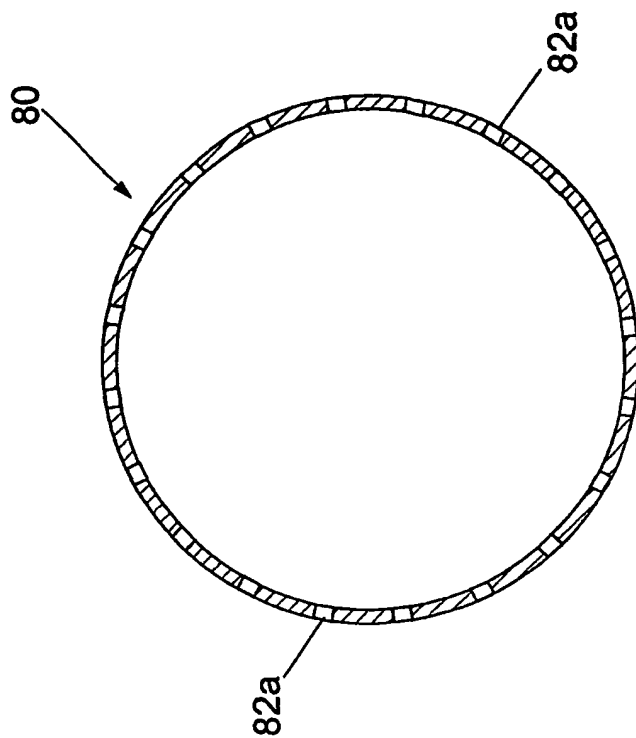


Fig. 4b

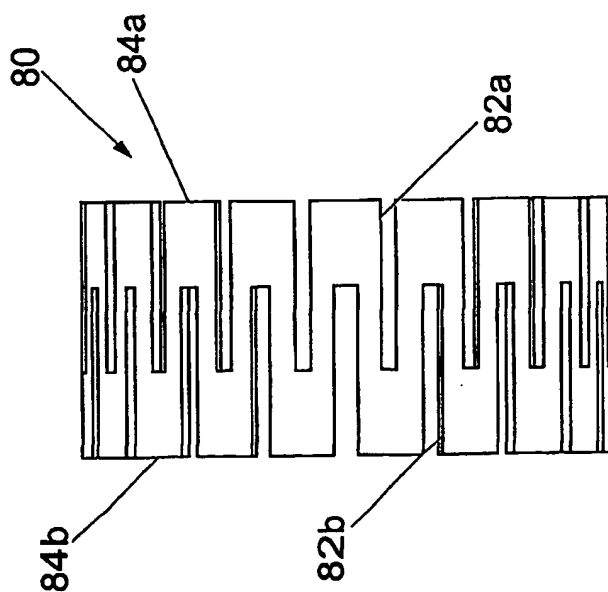


Fig. 4a